CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-110

March 15, 1981

1. Name of faults.

Calaveras, Pleasanton and Sherburne Hills faults (Diablo quadrangle)

2. Location.

Diablo 7.5 minute quadrangle, Contra Costa County (Figure 1).

3. Reason for evaluating.

New information indicates the need to re-evaluate the Special Studies Zone established in 1974. Also, part of a 10-year fault evaluation program (Hart, 1980a).

4. References.

Brabb, E.E., Sonneman, H.S., and Switzer, J.R., Jr. 1971, Preliminary geologic map of the Mount Diablo-Byron area, Contra Costa, Alameda, and San Joaquin Counties, California: U.S. Geological Survey Basic Data Contribution 28.

Clark, B.L., 1935, A preliminary study of Mount Diablo and Byron quadrangles, middle California: Unpublished maps and manuscript in Map Room file in San Francisco, CDMG. [Erroneously citied as a U.C. Berkely MA thesis on the Diablo SSZ Map.]

Dibblee, T.W., Jr., 1980, Preliminary geologic map of the Diablo quadrangle, Alameda and Contra Costa Counties, California: U.S. Geological Survey Open-File Report 80-546.

Ellsworth, W.L., and Marks, S.M., 1980, Seismicity of the Livermore Valley, California region 1969-1979: U.S. Geological Survey Open-File Report 80-515, 42p.

Ford, R.S., and Hills, E.E., 1974, Evaluation of groundwater resources--Livermore and Sunol Valleys: California Department of Water Resources Bulletin 118-2, 153p.

Ford, R.S., et al., 1970, Livermore and Sunol Valleys, evaluation of

Figure 1 (FER-110). Locations of the Calaveras and Pleasanton faults zoned for special studies under the Alquist-Priolo Act (after Hart, 1980a) and study area of FER-110.

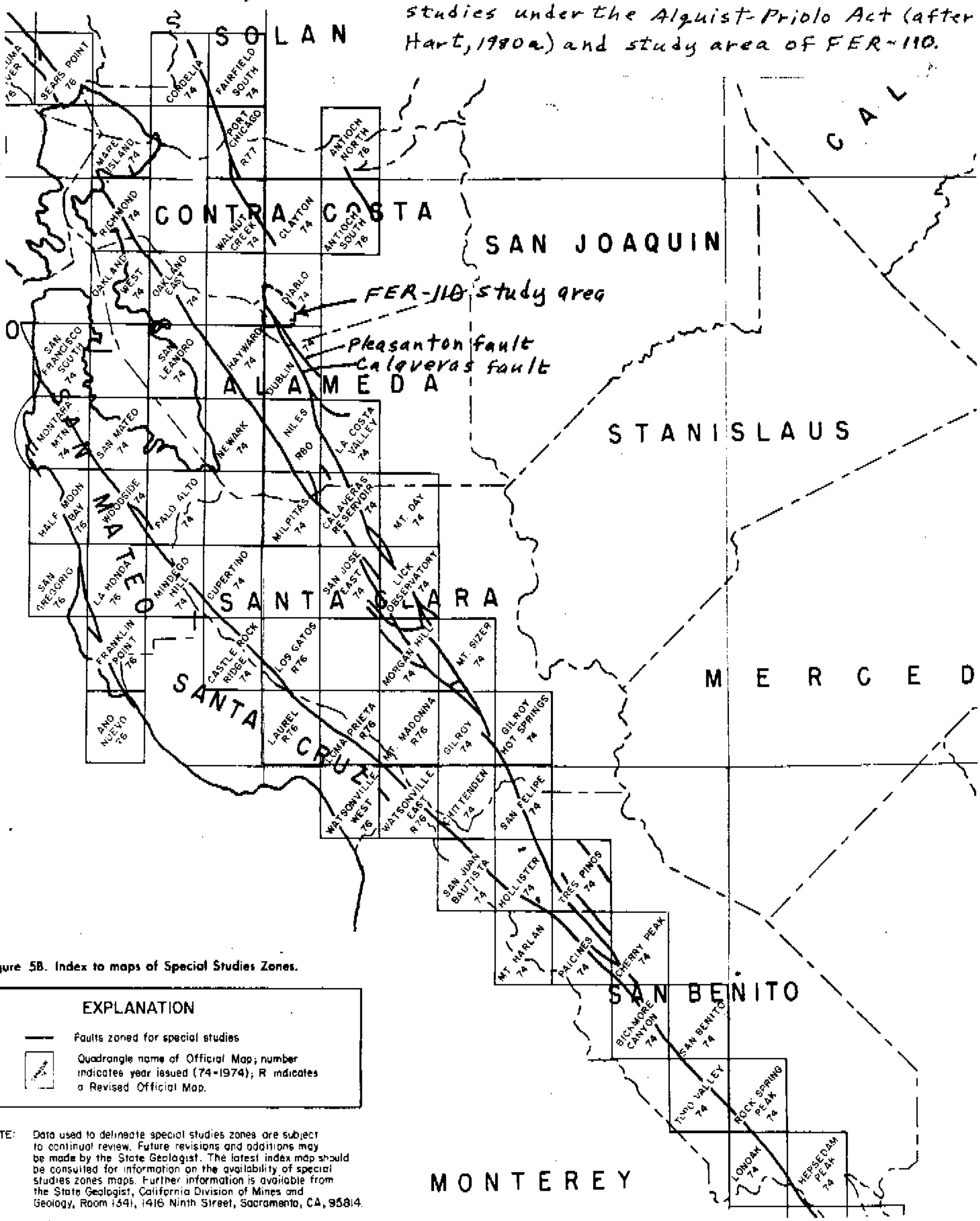


Figure 5B. Index to maps of Special Studies Zones.

EXPLANATION

Faults zoned for special studies

Quadrangle name of Official Map; number indicates year issued (74=1974); R indicates a Revised Official Map.

NOTE: Data used to delineate special studies zones are subject to continual review. Future revisions and additions may be made by the State Geologist. The latest index map should be consulted for information on the availability of special studies zones maps. Further information is available from the State Geologist, California Division of Mines and Geology, Room 1341, 1416 Ninth Street, Sacramento, CA, 95814.

Scale 1:1,000,000

1 inch equals approximately 16 miles

ground water resouces through 1968: California Department of Water Resources, Memorandum Report (modified by R.S. Ford, 1973, personal communication).

Geological Society of Sacramento, 1964, Guidebook and field trip to the Mount Diablo area, with geologic map (1:48,000).

Haltenhoff, Rick, 1979a, The 1861 (?) surface break of the Calaveras fault, San Ramon, California in Geologic Cordilleran Section guidebook, April 1979, p.63-73.

Haltenhoff, R., 1979b, The San Ramon Valley fault, California in Recent Deformation along the Hayward, Calaveras, and other fault zones, eastern San Francisco Bay region, California: Geological Society America, Cordilleran Section, April 1979 meeting, field trip guide, p. 61-62.

Hansen, W.R., 1966, Livermore and Sunol Valleys, evaluation of ground water resources: Geology: California Department of Water Resources, Bulletin Number 118-2, Appendix A (Geology), 79p., plates.

Hart, E.W., 1980a, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 25p.

Hart E.W., 1980b, Calaveras fault, Las Trampas Ridge quadrangle: California Division of Mines and Geology, Fault Evaluation Report FER-100 (unpublished report on file at San Francisco-District Office).

Hart, E.W., 1980c, Calaveras and Verona faults, Dublin quadrangle: California Division of Mines and Geology, Fault Evaluation Report FER-108 (unpublished report on file at San Francisco District Office).

Hart, E.W., 1981, Pleasanton and related faults, Dublin quadrangle: California Division of Mines and Geology, Fault Evaluation Report FER-109 (unpublished report on file at San Francisco District Office).

Herd, Darrell, 1978, Map of Quaternary faulting along the northern Calaveras fault zone, Las Trampas Ridge, Diablo, Dublin, Niles and La Costa 7.5' quadrangle, California: U.S. Geological Survey Open-File Report 78-307, five maps(no text) 1:24,000 scale.

Lee, W.H.K., Eaton, M.S., and Brabb, E.E., 1971, The earthquake sequence near Danville, California, 1970: Bull. Seismological Society of America, V.61, n.6, p.1771-1794.

Levish, Murray, 1973, personal communication.

Nilsen, T.H., 1971, Preliminary photo interpretation map of Landslide and other surficial deposits of the Mount Diablo Area, Contra Costa and Alameda Counties, California: U.S. Geological Survey Miscellaneous Field studies Map MF-310.

Smith, T.C., 1973, unpublished field mapping and air photo interpretations, Dublin quadrangle: California Division of Mines and Geology.

Trask, J.B., 1864, Earthquakes in California from 1800-1864: Proceedings of the California Academy of Sciences, V.3, p.130-153.

U.S. Department of Agriculture, 1939-1940, black and white aerial photographs, vertical, scale 1:20,000 (approximately), BUU-279-108 to-114, 280-8 to-12, 281-89 to-93, 337-6 to-13, (Available from National Archives, Washington D.C.).

U.S. Department of Agriculture, 1950, black and white, vertical aerial photographs, scale 1:20,000 (approximately); BUU-4G-130 to-135, 5G-10 to, -19, 5G-62 to-66.

U.S. Geological Survey, 1973, Low-sun angle, color, vertical photos, scale approximately 1:20,000 1-15 to 1-22, 1-58 to 1-65 and 11-94 to 1-104, flown 9-21-73. (Obtained from Rapidcolor, Burbank, CA).

Wagner, J.R., 1978, Late Cenozoic history of the Coast Ranges east of San Francisco Bay: Unpublished PhD thesis, University of California at Berkeley, 161p., 12 maps (1:24,000 scale).

5. <u>Review of available data.</u>

Special Studies Zones (SSZ's) were established for the Calaveras and Pleasanton faults in the Diablo quadrangle in 1974. These zones were based on five sources of fault-trace information, identified on Figure 2. The Calaveras fault traces are from Clark (1935), Ford, et al (1970), Brabb, et al (1971), and Smith (1973). The work of Ford, et al (1970), Smith (1973) and Levish (1973) served as a basis for zoning the Pleasanton fault. Much of this work was unpublished and there was little agreement as to the location of the surface and near surface traces of these faults.

The 1974 fault-zoning was done by Ted Smith under the supervision of this writer. CDMG's policy at that time was to zone all Quaternary traces of the Calaveras fault. The Pleasanton fault was zoned because of its proximity to the Calaveras fault. Because of the limited time available to identify the principle surface faults, a single zone one to two miles wide was established.

Mapping and numerous site investigations since 1974 indicate that many of the inferred traces shown on the SSZ maps are mislocated or do not represent active faults. Moreover, CDMG's current policy is to zone only surface and near surfaces faults considered to be sufficiently active and well-defined (Hart, 1980a, p.5-6). This study presents new interpretations as to the locations of surface faults and evaluates the existing data in the context of the present zone policy.

The Calaveras fault has been mapped as a major right-lateral strike-slip fault, extending from Hollister on the south to San Ramon or Danville. Its northwestern extent and even its location is controversial. Various interpretations exist for the northwestern part of the fault and these interpretations are summarized by Hart (1980b, 1980c) for the Las Trampas Ridge and Dublin quadrangles to the west and south of the Diablo quadrangle.

Perhaps the first detailed geologic mapping (1:62,500 scale) of the Calaveras fault in the study area was by B.L. Clark (1935). He mapped several strands of the fault north of Crow Canyon Road, the main fault being used on the SSZ map (Figure 2). He mapped a single strand to the southeast similar to the west strand of Dibblee (1980) plotted on Figure 3. Clark shows the fault to be a major geologic discontinuity, and suggests evidence of recent horizontal slip based on "well-defined scarps" and sag pond (not clearly identified). Clark's unpublished work is erroneously citied on the SSZ map (Figure 2) as a U.C. Berkeley MA thesis. Clark does not show the Pleasanton or Sherburne Hills faults on his map.

The Geological Society of Sacramento (1964) shows the Calaveras fault as a dashed line in the middle of San Ramon Valley on their compilation map. They also do not show the Pleasanton or Sherburne Hills faults. The Calaveras fault trace is obviously generalized and therefore is not plotted on Figure 3. This work suggests the lack of knowledge about the Calaveras fault in San Ramon Valley as recently as 1964.

Hansen (1966) shows the Calaveras fault as concealed under alluvium similar to Ford, et al (1970), which was a source of data used on the SSZ map. However, Hansen does not show the Pleasanton fault to extend northward into the Diablo quadrangle.

Concealed traces of the Calaveras and Pleasanton faults and an interconnecting fault of Ford, et al (1970) were used on the 1974 SSZ map, Diablo quadrangle (Figure 2). This work was later published by Ford and Hills (1974). Apparently the Calaveras and Pleasanton faults were projected northward from data obtained in the Dublin quadrangle, as no justification is given for specific fault locations in the Diablo quadrangle. According to Robert Ford (1981, personal communication), the fault-trace locations in the Diablo quadrangle were inferred, based partly on geophysical data. According to Ford and Hills (p. 126), the concealed interconnecting fault does not act as a ground water barrier. There is no indication that the faults shown by Ford, et al. are based on surface or near surface evidence of fault rupture. Trench exposures do not reveal the existence of any of these faults in young alluvium (Figure 2, Table 1).

Brabb, et al (1971) also show a concealed trace of the Calaveras fault, which was used on the 1974 SSZ map (Figure 2). At least five trenches excavated across this trace reveal no evidence of near surface faulting in young alluvium (Figure 2, Table 1). Brabb, et al do not show the Pleasanton fault on their map. They do show a Sherburne Hills fault to the east and an unnamed fault nearby (Figure 3), but do not indicate that these faults offset alluvium. Trench investigations by Harding-Lawson (report AP 235, Figure 3, Table 1) confirm faulting in bedrock in the vicinity of these faults, but present no clear evidence of offset soil or alluvium.

Two strands of the Pleasanton fault used on the 1974 SSZ map (figure 2) were based on the work of Levish (1973). These trace are similar in location to the faults identified in an unpublished consulting report of Burkland and Associates, for whom Levish worked (report C-3, in Figure 2, Table 1). This work, which presumably supercedes Levish (1973), is discussed below.

A principal sources of data for the 1974 SSZ map was T.C. Smith (1973), who interpreted high altitude aerial photos and did very limited field checking. The photos used and the specific features interpreted are not recorded in CDMG files. As a result, Smith's interpretations are difficult to evaluate. Trench excavations have verified some of Smith's traces, particularily along the Calaveras fault, but many of his interpreted photo lineaments do not appear to be faults (see trench data, Figure 2 and Table 1). Some clearly are drainage features, particularly in the San Ramon Valley. Others are cultural features. There appears to be no useful purpose in discussing each of Smith's 26 separate traces. However, addition discussion on the interpretation of aerial photos appears under Section 6, below.

A recent interpretation of aerial photos was made by Herd (1978) who attempted to identify Quaternary strands of the Calaveras and other faults. Herd shows several discontinuous traces for the Calaveras fault, based primarily on geomorphic features (identified on Figure 3). A southernmost trace is concealed, being identified as a linear NE-facing scarp in a landslide. Two trenches by Terrasearch (report Ap-690) did not confirm this as a recent fault. Three short en echelon traces were mapped just south of Norris Canyon Road based on "notches" and "sags" in bedrock terrain. The two westerly traces partly coincide with the main active trace of the Calaveras fault as identified by Terrasearch (AP-690). Herd's trace just north of Crow Canyon Road, which coincides with this writers' active trace, is inferred from linear scarps and a valley and a saddle. The southern end of this trace is confirmed in trenches of Engeo (AP 879 in Figure 3 and Table 1). Herd was not able to trace the fault northward through extensive landslide deposits (shown on Figure 4). Just south of Danville is a short concealed trace (queried) at the base of a slope, which Herd identifies as scarps in two places (Figure 3). This trace coincides with a fence line observed on USDA (1950) photos, which do not indicate that the scarp is particularly linear or continuous. Trench excavations on-trend to the northwest did not reveal evidence of recent faulting in alluvium (AP 324, 420 and 737, Figure 3 and Table 1). A shallow trough and saddle (in bedrock) just north of Danville was interpreted as a fault by Herd. However, there is no evidence of recent offset and the features appear to be erosional (old fault or weak beds). Herd does not provide evidence for the Pleasanton or any other recent fault in the Diablo quadrangle.

Herd also located the house of Dr. Larabie (Figure 3), near which a large earth-fissure reportedly opened during the 1861 earthquake (Trask, 1864, p. 150). The exact location or trend of this fissure is not known and it may be related to landslide movement triggered by shaking. The 1861 (?) date on the trace of Smith (1973) (see Figure 2) also is inferred.

Wagner mapped part of the Calaveras fault in his 1978 thesis and one of his traces partly coincides with the main active trace identified in Figures 3 and 4. He also mapped a fault near the Sherburne Hills fault of Brabb et al (1971), but only the western part of the latter coincides with Wagner's trace. Wagner shows no faults near the Pleasanton fault of other workers. Because Wagner's work was not directed at determining fault recency (Wagner, p.c., 1980) and is incomplete his traces are not plotted or evaluated. The location of his faults and designation of bedrock units contrast with Dibblee (1980), Brabb, et al (1971) and Clark (1935), suggesting the complexity of structure and stratigraphy in the southwest part of the Diablo quadrangle.

Dibblee (1980) provides the most recent geologic map of the Diablo quadrangle, although the map is based partly on the work of others. He shows several strands of the Calaveras fault and a trace of the Pleasanton fault (Figure 3), all of which are concealed or inferred. There is no text provided and the evidence for the faulting can only be inferred. However, Dibblee's map does reveal a major discontinuity along the west side of San Ramon Valley and large-scale right-lateral drag in the Tertiary units. Moreover, Dibblee's map also reveals that the strata northeast of San Ramon Valley are part of a conformable sequence of Cenozoic strata that have been uplifted, partly overturned and folded as a result of major uplift of Mount Diablo. Although the strata may be internally sheared and cut by numerous faults, as indicated by trenching and air photo interpretation, the lateral continuity of beds and units appears to be relatively intact. Dibblee shows no faults in the Dougherty or Sherburne Hills. Several of Dibblee's faults have been trenched and were shown not to be active or to be mislocated. However, his faults locally coincide with faults of others.

Numerous site investigations have been made in the Diablo quadrangle in order to identify active strands of the Calaveras and Pleasanton faults. More than 50 site-investigation reports on file at CDMG reveal that hundreds of trenches have been excavated for faults (Table 2 and Figure 2 and 3). These reports provide considerable information on the presence or absence of faults and the recency of activity, although some of the data are conflicting and questionable. Other site-investigations reports are on file at CDMG, but they, do not indicate that trenching was employed. Additional reports exist but were not filed with CDMG. Those reports providing particularly significant data on fault locations are discussed below. Reports indicating the existance or absence of faults are identified on Figures 2 and 3 and are briefly discussed in Table 1. The CDMG file numbers (AP or C) are also identified on Figures 2 and 3 and Table 1.

Calaveras fault.

Reports by Terrasearch of 1977 (AP 690) and 1977-1979 (AP 404) locate the main active trace of this fault as shown on Figure 3. Figure 2 shows other faults considered to be potentially active. Several trench logs from these reports reveal offset soil units along NW-trending, vertical to SW-dipping faults. However, the active fault strands are obscured by landsliding or grading in some cases. Also, the zone of bedrock faults is very wide at AP 404 (see Figure 2). Nonetheless, the building setback zones closely match the principal fault features identified south of Crow Canyon Road on Figure 4.

North of Crow Canyon Road, Engeo, Inc. (1977-1979, AP 619) identified a complex fault zone with offset soil units in at least three trenches near the toe of the NE-facing scarp of Herd (1978) and this writer (Figure 4). They project this fault due north, but evidence of recent faulting was not exposed in the eastermost trench of AP 879 and the long trench of AP 410 (Figure 3). However, logs of two trenches of AP 879 reveal anomalous conditions (soil thickening, sheared rock, collapsed trench) that exactly align with right-laterally offset drainage believed by this writer (Figure 4) to be the location of the main active fault.

Based on a 1978 investigation, Berloger, Long & Associates (C-424; Haltenhoff, 1979a) believe they located the 1861 (?) trace of the Calaveras fault and a possible minor branch (Figure 3) fault just north of San Ramon. Haltenhoff cites offset soil, truncated, bedding, shears, gouge, slickensides, and caliche veins in three trenches along a "linear, saddle" as evidence of recent faulting. A minor east-branching fault also was inferred to be recently active based on evidence in three other trenches, but the evidence for recency and fault continuity is not convincing. These two faults lie within a massive landslide mapped by Herd (1978) and verified on aerial photos by Nilsen (1971) and this writer (Figure 4). The gently dipping slip surfaces, pull-apart features, and chaotically mixed units revealed on the trench logs (Haltenhoff and C-424) are more suggestive of complex downhill movements rather than recent faulting. Even so, evidence of Holocene activity along the western trace is clear. The linear saddle (actually a side-hill trough) is not inconsistent with deep, large-scale sliding. The earth fissure reported by Trask (1864) after the 1861 earthquake also is not inconsistent with the pull-apart, structures (soil-filled fissures) exposed in the trenches, although the exact location of the 1861 fissure is uncertain. Haltenhoff (p.72) cites young geomorphic features (several offset streams, scarp, etc.) as evidence of the 1861 (?) fault. Contrarily, aerial photos and topographic maps do not show a systematic right-lateral offset of drainages or a scarp. Moreover, the 1861 (?) trace was not identified where expected to the southeast in trenches at AP 662, AP 1279 (east trench), and AP 410. However, faults exposed in the westernmost trench of Engeo (AP 1279) was considered to offset the soil two-to-three inches and may be a possible southward estension of the Berloger, Long trace.

Terrasearch, Inc. (1977; C-423), in a prior investigation at the Berloger, Long site, concluded that the anomalous features observed in their trenches were caused by shallow-landsliding, rather than faulting.

As mentioned above, Engco (1977, AP 1279) identified two bedrock faults which they considered to be possible en echelon branches of the 1861 (?) fault of Berloger, Long to the north. However, their log of trench three shows the western fault to offset the soil only three inches (down to the west). The eastern fault reportedly offset the soil two inches (east side down), although the log suggest only a soil thickening over a bedrock depression at the fault. These minor recent offsets could be due to minor downhill adjustments along old faults, as the Engeo faults appear to lie within, but near, the scarp of a large, complex landslide (Herd, 1978; Nilsen, 1971; Figure 4).

Pleasanton fault.

There is considerable doubt as to the existence of the Pleasanton fault, as mapped by Ford (1970) and Smith (1973), as indicated above. If such a fault exists, trench data indicates that recent faulting is both discontinuous, minor, and not systematic in sense of offset. A similar conclusion was drawn to the south (Hart, 1980c). Haltenhoff (1979b) believes that these discontinuous faults, which occur on the west flank of the Dougherty Hills, form an en echelon set of vertical faults with right-lateral and vertical (east-side up) components of slip. He attributes the faults to the Mount Diablo piercement and proposes that they collectively be referred to as the San Ramon Valley fault. The proposed nomenclature is not used in this study.

Trench investigations that provide evidence for recent faulting along the southwest flank of the Dougherty Hills are discussed from south to north. None of the faults identified clearly offset younger alluvium.

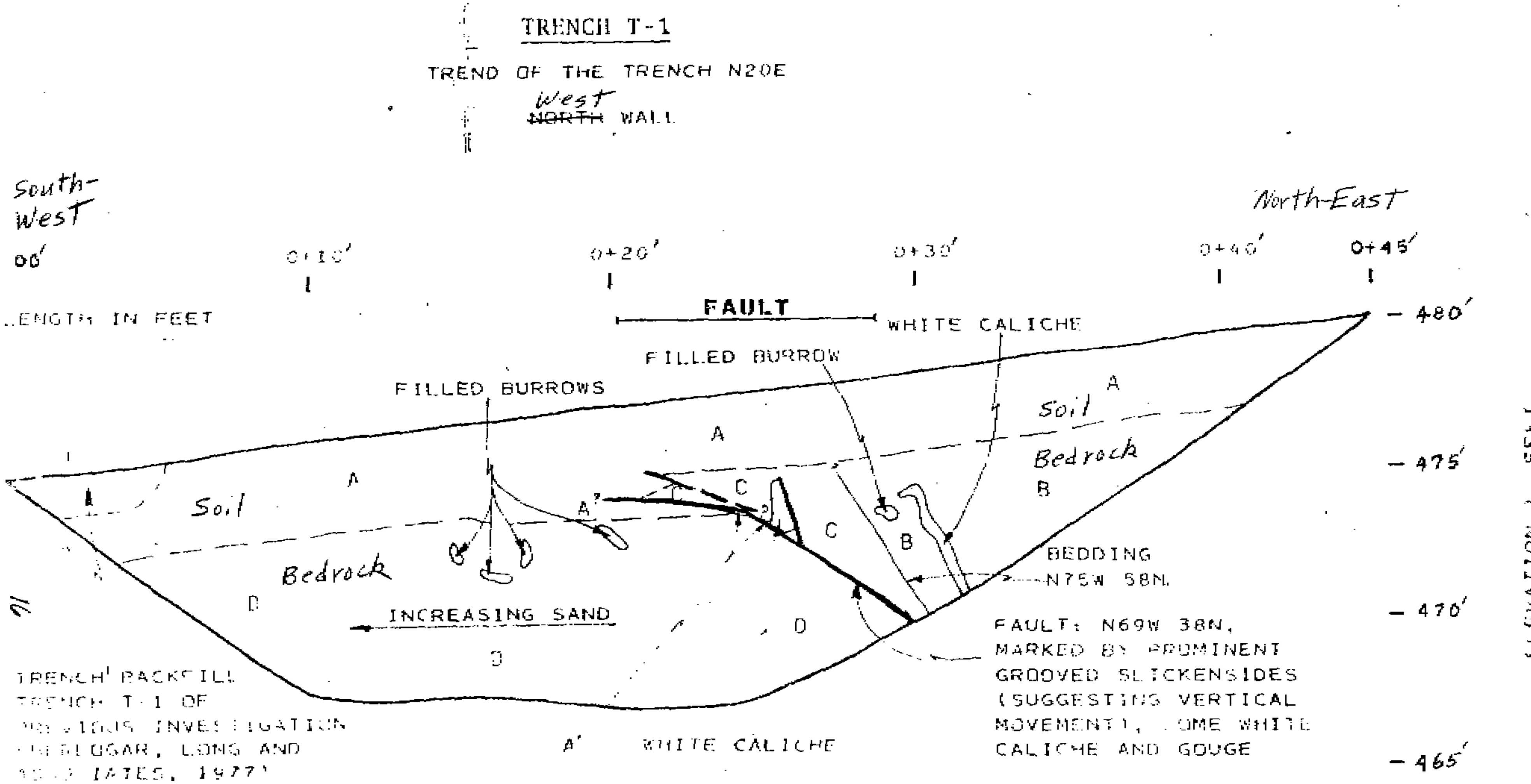
Terrasearch (1976-1979; AP 790) reported a northwest-trending fault and recommended a building setback zone based on faulted and brecciated Pliocene bedrock (Orinda Formation) observed in four or five trenches and a soil step in one trench. The continuity of the fault mapped (Figure 3) is questionable and many other bedrock faults and shears are present beyond the setback zone. Their geologic map (Figure 1) shows a bedded sequence of claystone, siltstone and sandstone to cross the fault uninterrupted. They were unable to follow the inferred fault to the southwest in bedrock. The faults exposed show varied dips from vertical to moderately to the northeast. Although Terrasearch states that a photo lineament extends from the northwest through the central part of the site and coincides with the mapped fault, no evidence of a distinct tonal lineament or recent fault related geomorphic features were observed by this writer on aerial photos (USGS, 1973; USDA, 1950) to coincide with the mapped fault. Faint tonal lines do cross the mapped fault diagonally (Figure 4), but there is no reason to believe they represent active faults.

Burkland and Associates (1973; C-3) mapped recently active faults, based on widely separated trenches and interpretation of aerial photos, and recommended three building-setback zones. The two westerly zones are plotted on Figure 3. Their easterly zone coincides with a zone of Berloger, Long & Associates (1977-1978, AP 689; discussed below). The westernmost fault zone of Burkland is exposed in two trenches as several parallel faults of variable dip that offset alluvium and soil (NE side up). It also is marked by a tonal lineament, which is similar to the western trace of Levish (1973). A trench of Berloger, Long failed to reveal evidence of this fault in young alluvium to the northwest, but they concur with the location and recency of the fault to the southeast. The central fault of Burkland only offsets bedrock and does not disturb alluvium to the northwest. The ground-rupture potential of these faults is considered to be "minimal to moderate" by Burkland (p. 18-19). Also, the faults were not believed to be the Pleasanton fault. Rather, they were considered be "part of a series of en echelon faults...related to the Mount Diablo piercement."

Berloger, Long (1977-78; AP 689) did additional trenching on the site (Figure 3) and concluded that only one main active fault existed, connecting Burkland's eastern trace with the southern part of their western trace. The other active traces of Burkland were considered not to "exist, in the number and locations as previously shown." Eight trenches cross the northern 2500-foot segment of the main fault, and only two trenches show offset of alluvium of undetermined age. None of the faults offset the topsoil unit. Many of the faults dip gently to moderately to the northeast and presumably have a dip-slip component. The mapped continuity and linearity of this fault segment are questionable because of the variable dips, the presence of other bedrock faults and shears, and the distance between trenches (up to 600 feet). The same problem exists with the short, arcuate fault 100 feet to the west, which was crossed by six trenches. The interpreted faults dipped 48° SW to 50° NE and only one exposure indicates offset of the soil bedrock interface (4 inches, down to the SW). Another trench did not identify the fault and two trenches showed only bedding-plane shears.

The southern segment of the Berloger, Long (1977-1978) fault was projected 3100 feet to the southwest (no interviewing trenches), where it was exposed by four trenches (mostly short). Two of the trenches show bedrock faulted against alluvium (undetermined age) and the faults dipped 53-59° S. All the other faults, which dip variably from 45° SW to 38° NE, are confined to bedrock. In no case is a soil unit offset by a fault, although a small soil step exists near a fault in one trench. The consultant concludes that the fault is active and the features observed were explained by a combination of dip-slip and strike-slip movement relating to the Mount Diablo uplift and right-slip along the Calaveras fault, although the sense of slip on most faults could not be determined. They also conclude that the mapped faults are en echelon (i,e, discontinuous), that faulting is complex, and that flexural slip (shears and faults parallel to the bedding) has occurred away from the mapped faults.

Just north of Watson Canyon, trench investigations of Berloger, Long (1979; C-422) indicate that the previously discussed fault extends N70°W and is a north dipping thrust. Two trenches exposed bedrock to be thrust over soil by two to four feet.(Figure 5). Two other trenches on trend also reveal north east dipping faults, but the soil is not clearly offset. Landslides were identified uphill from the fault.



EXPLANATION
TRENCH T-1

A SOIL: SANDY CLAY WITH RARE HIGH PLASTICITY.

Figure 5 (FER-110). Log of Trench exposing offset soil along Pleasanton fault at mouth of Watson canyon, investigative site C-422 (after Berloger, Long & Assoc, 1979),

Figure 5 (FER-110)

Two short en echelon fault (?) zones over a mile to the northwest of C-422 were considered to be potentially active by Terrasearch (1979-1980; AP 1100) and "building-control" zones were recommended. No distinct recent faults are identified in trench logs, although north-dipping slickensided fractures were reported in the steeply NE-dipping Orinda Formation and in thick, overlying soils. No evidence was presented to demonstrate that the minor fractures were related to recent faults, but special building foundations were recommended as a precaution. Trenches in young alluvium on-trend with and between the zones did not expose any faults. Recent active faults were not identified to the northwest or southeast of the AP 1100 site (Figure 3) in other trenches.

Sherburne Hills fault.

This fault and an unnamed fault to the southwest were mapped by Brabb, et al (1971), as discussed above and shown on Figure 3. Harding-Lawson Associates (1973; AP 235) mapped two "recently active" fault zones, for which building setbacks were recommended. These faults were identified as recent based on a sag pond, an offset drainage, unspecified topographic features and proximity to the Sherburne Hills fault of Brabb, et al. Subsequent trenching (mostly short trenches) confirms the presence of northwest-trending fault zones and shears in bedrock at widely separated points. However, no evidence was presented that demonstrated recency (e.g. offset soils). Because faults also were identified outside the mapped zones, the fault zones, mapped may not be as well-defined as indicated in the report.

6. Interpretation of aerial photographs; field observations.

Aerial photographs of the U.S. Department of Agriculture (USDA, 1939-1940; USDA 1950) and U.S. Geological Survey (1973) were carefully interpreted stereoscopically to identify those geomorphic features permissive or mandatory of recent faulting. Linear tonal features believed to be related to faulting also were identified. These data are plotted on Figure 4 and summarized below:

Calaveras fault. Using geomorphic features the most active trace of this fault can be located with reasonable confidence in several places along the west margin of San Ramon Valley (Figure 4). The southernmost 3000-foot segment of the fault is defined by a linear sidehill bench and other ephemeral features and has been verified in part by trenching. This trace is partly obscured by landslides. The weak tonal lineament and modified scarp to the east may not be fault related, as suggested by trenching at the north-end.

To the north, the main trace may be somewhat complex, but it is defined by a linear zone of scarps, offset drainage, closed depression, and tonal lineaments south of Norris Canyon Road. Trenching has verified this segment in part, although Terresearch (AP 404) locates the main trace as much as 200 feet to the west locally (Figure 3). The other tonal lineaments and troughs identified on Figure 4 apparently are at least partly fault-related, but trenches did not indicate the presence of active faults.

Between Norris Canyon and Crow Canyon Roads, tonal lineaments and vegetation contrasts in Holocene alluvium suggest the location of the active fault trace. This has not been verified by trenching.

North of Crow-Canyon Road a short segment of the main trace is strongly indicated by a very linear scarp which aligns with right-laterally deflected drainages, and tonal features. Trenching has partly verified the trace in young alluvium of probably Holocene age.

The active trace appears to continue to the north-northwest through a linear trough and a linear zone of scarps, benches, deflected and beheaded drainages, and short tonal features in a massive landslide complex. However, recent downhill movements obscure the precise location of the fault in most places. The fault could not be traced with confidence to the northwest in the Las Trampas Ridge quadrangle (Hart, 1980b).

The linear trough on the northeast flank of Las Trampas Ridge appears to be a fault zone, but significant systematic Holocene displacement (either strike-slip or dip-slip) appears to be precluded by the lack of recent scarps or deflected drainages (Figure 4). Although trenching by Berloger, Long (C-424; Figure 3) indicates minor recent displacements of soil, much of this is non-systematic thrusting toward the northeast and pull-apart features, which best indicate complex downhill movements. The inferred branch fault of Berloger, Long (Figure 3) cannot be identified as a recent fault on aerial photographs.

The northeast-facing scarp of Herd (1978) south of Danville (Figure 3) appears to be due to the existence of resistant strata that dip vertically and strike northwest. It does not extend into the alluvium to the northwest or southeast. Trenches in alluvium to the northeast did not find a fault on-trend with the scarp. The scarp's linearity is artificially enhanced by a fence line, which is the margin of a former orchard.

The linear trough and saddle mapped by Herd (1978) north of Danville (Figure 3) appears to be erosional along weak beds or an old fault zone. It is not associated with systematically offset drainages or scarps.

Pleasanton fault. There is no evidence of a well-defined or throughgoing fault along the northeastern margin of San Ramon Valley, as mapped by others (Figure 2 and 3). Short linear tonals and discontinuous geomorphic features suggest distributive faulting, probably associated with tilting, folding and overturning of Pliocene strata resulting from the Mount Diablo uplift and drag along the Calaveras fault. There is no systematic offset of drainages, as might be expected with strike-slip faulting, and no systematic development of southwest facing scarps, as might be expected from reverse faulting (northeast dip). Numerous features (tonals, linear drainages, saddles) were observed on the aerial photos that are permissive of minor recent faulting but most likely due to differential erosion. Only a few of these features are identified on Figure 4 and only in the vicinity of the inferred recent faults. Most are related to bedding, although some are faults that truncate the beds. Such features can be mapped in other places away from mapped faults. Mostly, they cannot be uniquely associated with active faulting and the mapped faults can only be verified locally.

Observation of several trenches and a review of numerous trench logs verify distributive faulting and shearing, much of which is parallel to the bedding. It is this writer's opinion that some of the minor offsets (steps) reported at the soil/bedrock interface are due to minor downhill movements, some of which could result form earthquake shaking. Elsewhere, changes in soil thickness is the result of differential soil development over contrasting rock units, either at depositional or fault contacts.

Inferred faults in San Ramon Valley. Numerous faults were inferred in alluvium by Smith (1973), Ford (1970, Brabb, et al (1971) and Dibblee (1980). Where these features can be verified on USDA 1939-1940 and 1950 photos, they are mostly vague and discontinuous, and appear to represent recent stream channels, and deposits. One such drainage is mapped on Figure 4 and clearly is not related to faulting. Others tonal features appear to be artificial (pipelines, fencelines, roads, etc.) and some of the inferred faults could not be verified at all. An analysis of each individual trace mapped by others seems unnecessary as all of the faults are inferred and many have been trenched, demonstrating the absence of faults in alluvium.

Sherburne Hills fault. There is clear evidence of truncated bedding observable on aerial photos (Figure 4) and some of the faults have been verified by trenching (AP 235; Figure 3). However, none of the faults can be traced very far and there is no evidence of systematic dip-slip or strike-slip displacement apparent in deflected drainages or scarps. A shallow closed depression on a north tributary of Watson Canyon does not appear to be associated with recent faulting, although its origin is not immediately apparent. It does, however, lie along a fault zone. The tonal features mapped on Figure 4 are common elsewhere in the adjacent hills and it did not seem productive to map all of the features which may be permissive of minor recent faulting.

7. Seismicity.

According to Ellsworth and Marks (1980), the Calaveras fault is poorly defined by seismicity north of the Calaveras Reservoir. It is quite obvious from Figure 6 that strain is being released along the southern segment of the fault and where it branches to the Hayward fault northwest of Calaveras Reservoir.

In the Diablo quadrangle, most of the seismicity is to the east of the Calaveras fault, and may be interpreted in different ways, depending on the

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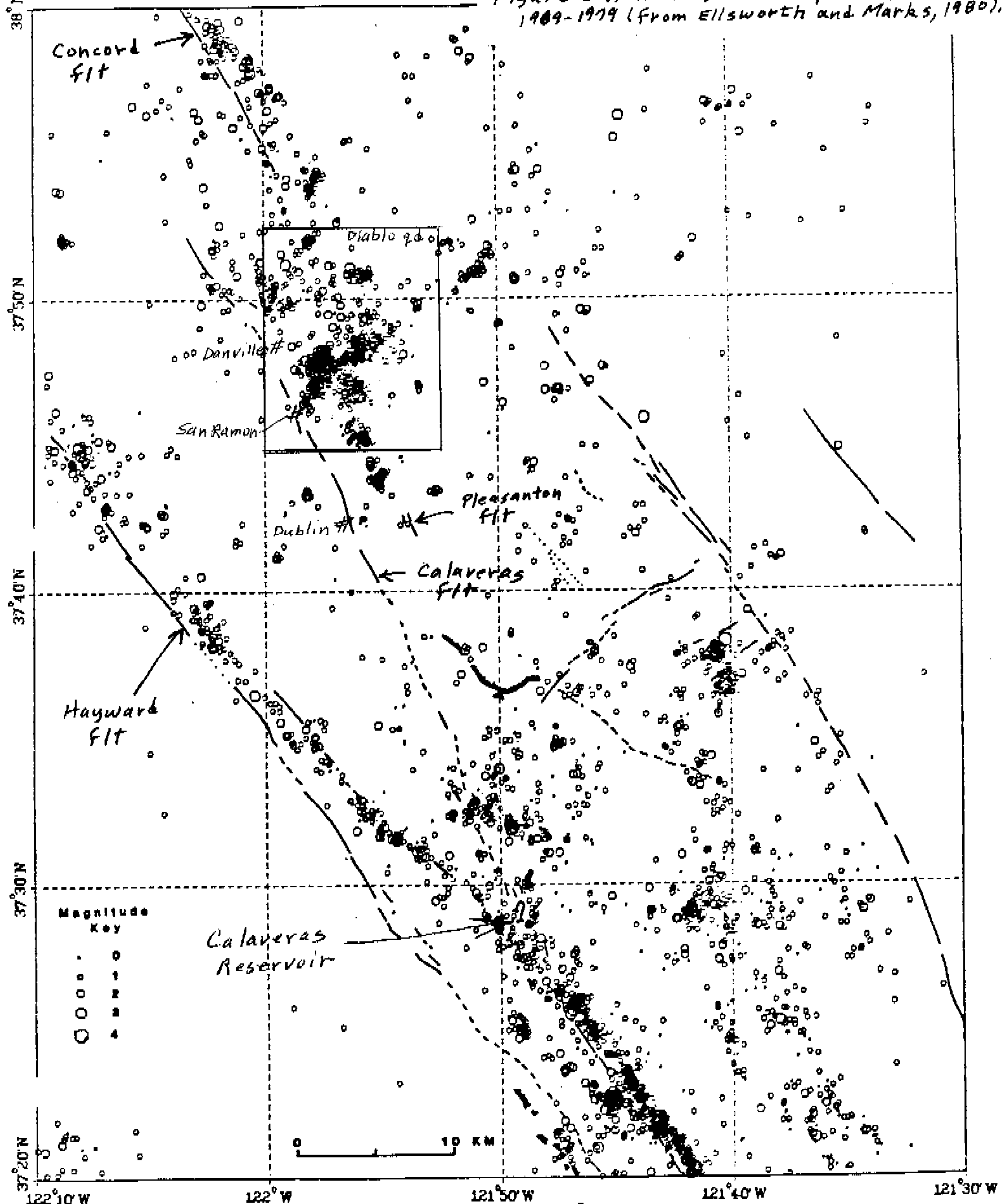
Figure 6 (FER-110). Earthquake epicenters 1969-1979 (from Ellsworth and Marks, 1980).



confidence in the epicenter locations. The zone of epicenters two to three km east of the Calaveras fault may be mislocated or the fault may dip steeply to the east. Alternately, this zone of epicenters may represent a northwest projection of the inferred Pleasanton fault. The first alternative is preferred by this writer, because focal mechanisms reportedly are "suitably oriented for right-lateral slip" (Ellsworth and Marks, p. 15) and the only significant active right-lateral fault mappable is the Calaveras fault (Figure 4).

Regardless of the details, strain along the Calaveras or other nearby fault appears to be transferring to the Concord fault in a right-stepping manner near San Ramon and Danville. The epicenter pattern east of Danville appears to suggest a northeast-trending fault. However, focal mechanisms of the Danville earthquake sequence of 1970, which accounts for much of this seismic "step," indicate right-slip on a N 35° W-trending fault (Lee, et al., 1971). This earthquake sequence was located five km southeast of Danville at a depth of six km below the Sherburne Hills, which is two to three km east of the projection of the Pleasanton fault.

Because no evidence of a through-going right-lateral fault can be mapped along the inferred northwest extension of the Pleasanton fault, which itself is inferred near Dublin (Hart, 1981), the epicenters located along this projection may be mislocated to the east. Nonetheless, Ellsworth and Marks (p. 18) speculate that the Pleasanton fault is "probably seismically active."

8. Conclusions.

Calaveras fault. The principal active trace of this fault is identified by a narrow zone of youthful geomorphic and tonal features in young alluvium in several places. Trench exposures have verified offset of recent alluvium and soils at several points along this linear zone. It is concluded that the Calaveras fault is Holocene active and moderately well-defined in most places in the Diablo quadrangle. Its northern end, however, is largely concealed by landsliding and an actvie trace of the fault cannot be traced beyond the map area.

The linear features east and west of the main trace south of Crow Canyon Road are partly due to faulting. Trench data suggests these features are either inactive faults or not due to faulting. The linear trough north of Crow Canyon Road, shown on the 1974 SSZ map as an 1861 (?) break, is a questionable active fault. It lies within a large, complex landslide that no doubt is still undergoing adjustments. Although it is not possible to prove this is not an active fault, there is no geomorphic evidence to suggest significant Holocene offset--either strike-slip or dip-slip.

Pleasanton fault. There is no evidence of a well-defined or through-going fault along the northwest projection of this inferred fault. Numerous discontinuous faults do exist along the western margin of Dougherty Hills. However, there is no geomorphic evidence of significant recent offset. If the fault is seismically active, as suggested by Ellsworth and Marks (1980), then geomorphic evidence of recent strike-slip displacement should be apparent. In spite of this, trench exposures indicate minor Holocene offset of soil and alluvial units along faults of variable dip (mostly to the northeast). Some of this offset may be due to minor downhill movement due to shaking or to landsliding. If active faulting has occurred during Holocene time, it is minor and distributive at the surface. Only between Watson Canyon and Coyote Creek is there geomorphic evidence faintly suggestive of recent faulting (Figure 4).

This evidence only partly coincides with the mapped recent faults based on trenching (C-422, C-3 and AP 689, Figure 3).

Inferred faults in San Ramon Valley. The general lack of geomorphic features and vagueness of tonal lineaments are suggestive of streams erosion and channel deposits, rather than of recent faults. None of the numerous trenches in the young alluvium verify the existence of any of the faults inferred by Ford (1970), Brabb, et al (1971), Smith (1973) or Dibblee (1980). It is concluded that there is no substantial evidence to support the existence of recently active faults in the alluvium of San Ramon Valley, except possibly along the northeastern margin between Watson Canyon and Coyote Creek (see Pleasanton fault above).

Sherburne Hills fault. Although northwest-trending faults have been mapped in bedrock along the southwest margin of the Sherburne Hills, these faults occupy a zone of somewhat discontinuous faults. The fact that this fault is mapped in different places (Figure 3 and 4) suggests that the fault is a poorly defined zone of faults. Other than a closed depression of unknown origin, there is no evidence that the faults in this zone were active during Holocene time. This interpretation is supported by trench observations indicating that soil units are not offset.

9. Recommendations.

It is recommended that the 1974 Special Studies Zone be revised to encompass those faults determined to meet the criteria of "sufficiently active and well-defined" (Hart, 1980a; p. 5-6).

Calaveras fault. Zone the main trace, as indicated on Figure 4, using the mapped trace of Terrasearch (AP 404, Figure 3) where their fault location is significantly different. With one possible exception, the branch faults identified or inferred on Figure 3 and 4 do not meet the criteria for zoning. The westerly branch fault of Berloger, Long (AP 424 on Figure 3) should be zoned as it apparently meets the zoning criteria. However, it is recognized that Holocene slip appears to be minor and the soil offset may be due to landsliding rather than faulting. The other branch faults should not be zoned.

Pleasanton fault. Zone the westerly branch fault of Burkland (C-3 on Figure 3), which is similar to a fault mapped by Levish (1973), as it is well-defined and offsets alluvium of possible Holocene age. Also, zone the main fault of Berloger, Long (C-422 and AP 689, Figure 3), which offsets alluvium and Holocene soil. There is no evidence that these faults meet the zoning criteria to the north or south of this locality.

Sherburne Hills fault. Do not zone this fault as it is not well-defined and apparently has not been active during Holocene time.

10. Report Prepared by: EARL W. HART, March 15, 1981

Earl W. Hart

Table 1 (FER - 110). Summary of unpublished fault-investigation reports that provide observational data on the Calaveras and other faults in the Diablo quadrangle and that are on file at CDMG, Ferry Building, San Francisco. Trenches referred to are plotted on Figures 2 and 3. File numbers refer to reports filed under the Alquist-Priolo Act (AP-) and other consulting reports. (C-).

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report(s)	Comments
AP 19	Burkland and Associates	Gonsalves property, San Ramon Siding	September 1974	270′ of trenches 10-15′ deep; no faults in alluvium or Orinda Formation.
AP 20	Burkland and Associates	G. Ball property, San Ramon Siding	March 1974 August 1974	710′ of trenches in NE-dipping beds of Orinda Formation; no active faults reported.
AP 32	Abel Soares and Associates	Ryan Industrial Court, San Ramon	November 1974	600′ of trenches; no faults reported, but set-back recommended.
AP 48	Burkland and Associates	Weightman property, San Ramon	November 1974	Two short trenches across lineament shown on SSZ map exposed unfaulted recent alluvium.
AP 94	Burkland and Associates	Tracts 4410 and 4476, Danville	May 1975	Short trench in alluvium; no faults
AP 122	United Soil Engineering	Tract 4477	June 1974 June 1975	Four short trenches, two of which cross lineaments shown on SSZ map; no faults in alluvium reported.
AP 148	Burkland and Associates	Tract 4411, San Ramon	August 1975	1250′ of trenches in young alluvium; no faults reported.
AP 153	Richard Rowland	Vaqal property, San	May 1975	Two short trenches in alluvium; no faults.
AP 154	Burkland and Associates	Tract 4336, Danville	October 1975	430′ long, , six to eight feet deep trench in alluvium; no faults.
AP 171	Engeo, Inc.	Tract 4383, San Ramon	December 1975	Grading cuts in Orinda Formation; beds dip 40-55°S; no faults.
AP 186	Harding-Lawson Associates	Cartan property, San Ramon	October 1975	Eight-foot deep trench in alluvium and soil; no faults reported.

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Table 1 (cont.)

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
AP 235	Harding-Lawson Assoc.	Danville Country Club	Oct. 1973	Numerous trenches 6-8' deep exposed steeply dipping Orinda beds cut by many faults that trend NW and dip steeply to moderately to NE and SW. Two zones of faults are mapped and these are considered potentially active based on sag pond and other general topographic features and seismicity. However, no soil unit is shown to be cut or offset.
AP 309	Burkland & Assoc.	Tract 4819, Danville	Apr. & Aug. 1976	480' long, 7' deep sewer trench in alluv; no faults reported.
AP 310	Terrasearch, Inc.	Alcosta & Montevideo, San Ramon	June 1976	700' long, 7-10' deep trench in young alluv; no faults.
AP 324	Applied Soil Mechanics	Podva (Sub. 4764), Danville	Dec. 1973	625' long, 10' deep trench in alluvium (mostly); no faults.
AP 339	Terrasearch, Inc.	San Ramon	Nov. 1976	140' trench in alluv; no faults.
AP 383	Terrasearch, Inc.	Montevideo & Broadmoor, San Ramon	Sept. 1976	660' trench, 8' deep in alluv; no faults.
AP 404	Purcell, Rhoades & Assoc. Terrasearch, Inc.	Bishop Ranch, San Ramon	Jul. 1976; Aug., Sept, Oct. 1977 and Apr. & Sept. 1979	Extensive trenching (some shallow) by Purcell, Rhoades, exposed numerous steeply-dipping faults in structurally complex units. Some faults were considered to be active. Subsequent trench investigations revealed additional faults and slightly revised conclusions were reached. Activity of faults and continuity between trenches is somewhat inconclusive, partly because grading had removed soil in some areas. Not all trenches shown on Fig. 2. Some reports not on file at CDMG.
AP 410	Engeo, Inc.	Subdiv. 4631, San Ramon	Jun. 1976	1350' trench, 10' deep in alluvium; crosses trace shown on SSZ map; no fault reported.

Table 1 (cont.)

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
AP 417	United Soils Engineering	Alcosta and Montevideo, San Ramon	Feb, Apr. 1977	150' trench in alluvium across concealed trace shown on SSZ map; no fault found.
AP 420	Engeo, Inc.	Subdiv. 4764, Danville	Apr. 1977 Oct. 1979	Three trenches identified on map; no fault found, but logs missing from reports.
AP 500	Engeo, Inc.	Subdiv. 5052, San Ramon	May 1977 July 1978	Several short trenches and sewer lines logged in alluv; no faults mapped, but fault assumed based on data of others.
AP 619	Engeo, Inc.	Sub. 5171 & 5526 (?), San Ramon	Dec. 1977 Nov. 1978 May 1979	Several trenches 3 or 4 of which exposed active trace of Calaveras fault close to lineament on SSZ map; bedrock fault with soil step above at break in slope.
AP 662	Burkland & Assoc.	Golden Skate; San Ramon	July 1974	Steeply dipping beds and clay-filled joints exposed in W part of trench; soil not offset; no fault reported.
AP 685	Terrasearch, Inc.	San Ramon Siding	Aug. 1976	2 trenches in young alluvium; no faults.
AP 689	Berloger, Long & Assoc.	Vista San Ramon, Sub. 5204	Dec. 1977 Jun., Aug. 1978	Several trenches reportedly exposed a NE-dipping reverse fault which was considered to be active (older (?) alluvium offset in one trench). Other faults found with variable strikes and dips (mostly NW), but little evidence for offset of overlying topsoil was shown. Consultant disagrees with Burkland & Assoc. rept (C-3) as to number and locations of faults. No picture of significant or systematic recent faulting is revealed by these trench logs.
AP 690	Terrasearch	Bishop Ranch, San Ramon	Oct. 1977	Main active trace of Calaveras fault exposed in several trenches; steeply dipping fault offsets soil locally; partly obscured by landsliding and soil creep, but coincides with mapped trace on SSZ map (Fig. 2).

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Table I (cont.)

CDMG file #	Investigation firm (or geelogist)	Site description and locality	Date of report (s)	Comments
AP 715	Kleinfelder & Assoc.	Danville	Feb. 1978	3 short trenches in alluvium; no faults.
AP 739	Applied Soil Mechanics (Burkland & Assoc.)	Danville	Jul. 1973	Extensive trenching in alluvium; no faults reported.
AP 749	Harding-Lawson Assoc.	San Ramon Valley Center	Dec. 1977 Feb. 1978	3 short trenches alluvium; no faults reported.
AP 790	Terrasearch, Inc.	Alcosta & Montevideo, San Ramon	May 1976 May, Jul. 1978 Dec. 1979	Extensive trenching of Orinda Fm. in hills exposed variably dipping beds and some fault evidence. Little if any evidence of recency is documented, although a setback zone was recommended. Many faults and shears are identified outside the setback zone. 3 trenches across lineament shown on SSZ map (at base of hills) did not reveal recent faulting, although trench logs suggest extensive faulting of Orinda Fm., but not of overlying alluvium and soil.
AP 843	Frank Stejer	Alcosta and Norris Cym Rd, San Ramon	Oct. 1978	Short trench in alluvium; no faults.
AP 845	Engeo, Inc.	Danville	Jan. 1978	Short trench in alluvium; schematic log; no faults.
AP 854	Engeo, Inc.	Danville	Dec. 1976	240' trench in bedrock and soils; no recent fault reported, but part of trench vy. shallow.
AP 859	United Soils Engineering	San Ramon	Sep. 1975, Aug, Nov. 1978	Sewer trench across lineament shown on SSZ map logged; no faults in alluvium. Lineament may mark trend of pipeline.
AP 875	Kaldveer & Assoc.	San Ramon	Nov. 1978	Shallow trenches across two traces shown on SSZ map; no faults in alluvium.
AP 876	Kaldveer & Assoc.	Safeway Store, San Ramon	Jul. 1978	350' trench in alluvium; no faults.

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Table 1 (cont.)

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
AP 877	Bay Soils, Inc.	San Ramon	Dec. 1978	900' of trenching in alluvium; no faults reported.
AP 879	Engeo, Inc.	San Ramon	May 1978	Extensive trenching, mostly in alluvium. Weak evidence of faulting found close to trace shown on SSZ map, but soil was judged not to be offset. Inconclusive.
AP 1100	Terrasearch, Inc.	Crow Canyon & El Capitan, San Ramon Siding	Mar, Aug. Sept. 1979	Extensive trenching in bedrock (Orinda Fm?) and alluvium/colluvium. Bedrock dips steeply NE and is pervasively sheared, overlying soils and alluv/colluv are not offset, although setback zones recommended.
AP 1101	Bay Soils, Inc.	Danville	Feb. 1979	2 short trenches in alluvium; no faults.
AP 1110	Engeo, Inc.	San Ramon	Jun. Dec. 1979	180'-long trenches in alluvium; no faults.
AP 1112	Kaldveer & Assoc.	San Ramon	Oct. 1979	550'-long trench in alluvium, 9' deep no faults found. Shorter trench to N from previous study (no log; no fault).
AP 1113	Kaldveer & Assoc.	Danville Medical Complex	Dec. 1979	290' trench in alluvium; no faults.
AP 1264	Harding-Lawson Assoc.	Bishop Ranch, San Ramon	Sept & Dec. 1979 Jan & May 1980	Extensive trenching, seismic refraction and magnetic profiling; no faults found in young alluvium.
AP 1279	Engeo	Edwards property, San Ramon	Jan & Feb. Oct. 1980	550' of deep trenches in bedrock and landslide deposits. No fault reported across trend of fault shown on SSZ map. However, 2 faults with minor offset of soil/rock interface identified to west. Fault lies near scarp of landslide of Herd (1978)

Table 1 (cont.)

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
				and recent offset may be caused by minor downslope movement.
AP 1280	Michael Hayes (P.G.-& E)	P G & E San Ramon Siding	Jan. 1981	222', 12' deep trench in alluvium; no faults reported. Also no faults reported in Kaldveer trench (for Aerotest) 250' to N (report not on file with CDMG).

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Table 1 (cont.)

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
C-3	Burkland and Assoc.	Winston Valley site, San Ramon	Nov. 1973	4200' of trenches 10' deep, extensive seismic refraction and magnetic profiling. Numerous faults in bedrock, some with possible minor offset of Holocene alluvium and soil/colluvium. No systematic sense of offset and faults have variable attitudes. Faults mapped are of questionable continuity and recency. Faults not traceable to NW in alluvium. Data supercedes Levish (p. c., 1973) used to compile SSZ map.
C- 414	Terrasearch, Inc.	Bollinger Canyon Elementary School, San Ramon	May 1979	Seismic refraction profiles indicates faulting at west end of property but not elsewhere. Map shows locations of trenches and Calaveras fault based on other investigations of Terrasearch.
C- 418	Merrill & Seeley, Inc.	Crow Canyon Commons, San Ramon	Mar. 1980	1800' of trenching, 10-14' deep in Holocene and latest Pleist. alluvium; no faults reported.
C-421	Earth Systems Consultants	Davidson property, San Ramon Siding	Oct. 1979	6-10' deep trenches expose NE dipping, internally deformed beds of Orinda Fm. overlapped by alluvium/colluvium. No faults reported. Some evidence of soil and rock creep.
C- 422	Berloger, Long & Assoc.	Church of Nazarene, Alcosta Blvd.	Nov. 1979	Thrust fault (N 70° W, 45° N dip) reported in 4 trenches; also small landslides to NE (uphill) and stratally ~~dis~~ rupted, folded beds to SW. Soil offset in 2 branches, and striations indicate recent dip-slip movement, but pervasive deformation and buried redbeds may suggest pervasive recent downhill movement (massive sliding?). Just S of Watson Creek a N78° W, 55°N-dipping, recent thrust-shear was mapped by Burkland & Assoc. in trench T-3 (see C-3).
C- 423	Terrasearch, Inc.	Peters Ranch	Aug. 1977	4 trenches to 200' long expose soil and Tertiary

CDMG file #	Investigation firm (or geologist)	Site description and locality	Date of report (s)	Comments
				bedrock units; no faults reported and 1861(?) trace shown on SSZ map considered not to exist. However, open cracks in bedrock and changes in soil thickness exist and may suggest recent movement. Some landslides mapped. Also see C-424 for alternate interpretations.
C- 424	Berloger, Long & Assoc.	Peters Ranch	Sept. 1978	11 short trenches (carefully logged) reveal highly deformed and jumbled bedrock units with numerous clay filled shears (vertical to subhorizontal). Based on disturbance of soil, 2 active faults, A (west) and B (east), are identified, as well as landslide units and slip planes. Fault B is questionable and A could be interpreted alternately as complex, late Quaternary sliding (which is identified locally Fault A coincides with 1861 (?) trace shown on SSZ map. Local overthrusting on soil-filled fractures suggest complex down-hill movements.